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Trisomy 10p: Report of an Unusual Mechanism of Formation and Critical Evaluation of the Clinical Phenotype

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A de novo tandem inverted duplication of 10p was diagnosed in a 17-week fetus. The appearance of GTG banded preparations and the results of fluorescence in situ hybridization (FISH) studies are consistent with duplication of the entire arm, including the telomere. The FISH studies also demonstrated the presence of chromosome 10 alphoid repeats at the junction between the inverted segment and the long arm, consistent with the presence of the entire long arm of the abnormal chromosome. Therefore, this is a case of pure trisomy 10p without an associated deficiency of any other chromosome segment. A comparison of the phenotype associated with pure trisomy 10p and trisomy associated with a duplication/deficiency state documented a higher frequency (of borderline significance) of clubfoot and high-arched/cleft palate in the cases of pure trisomy. The frequency of palatal anomalies was observed to be significantly higher in the cases where the breakpoint of the trisomic segment is in the most proximal band (10p11). However, other clinical manifestations were observed inconsistently, even in the cases with pure, nearly complete trisomy 10p. Therefore, a clearly defined trisomy 10p clinical syndrome could not be documented in this study.

KEY WORDS: trisomy, 10, high-arched/cleft palate, clubfoot, FISH

INTRODUCTION

A number of reports describing the clinical phenotypes of patients with trisomy 10p have appeared over the past two decades [1-17, 19–35, 37–38, 40, 42–46, 49–52]. However, the existence of a clearly recognizable trisomy 10p syndrome remains controversial; some authors have claimed that a consistent pattern of clinical findings is diagnostic of this chromosome aberration [7, 19, 44], whereas others, based on the extent of phenotypic variation in reported cases, have questioned the existence of a clearly defined clinical syndrome [51]. It is likely that the variation of manifestations observed in trisomy 10p may be related to the size of the trisomic segment and/or the presence or absence of an associated deficiency of chromosomal material. A "pure" trisomy (absence of associated monosomy) can arise by mechanisms such as tandem duplication or translocation to the short arm of an acrocentric chromosome, resulting in a trisomic state not associated with a deficiency of euchromatin at another site. Phenotype-karyotype studies of these pure 10p trisomies provide an approach to a more precise definition of manifestations associated with this aberration. In this report, we describe the occurrence of a pure trisomy of the entire short arm of chromosome 10 in a 17-week fetus. The clinical phenotype was evaluated as a function of the presence or absence of a deficiency of euchromatic material and also as a function of the length of the trisomic segment. Although some differences in the frequency of specific manifestations were observed, a clearly defined trisomy 10p clinical syndrome could not be defined.

CLINICAL REPORT

A 42-year-old G7,P5,SAB1 woman was referred for amniocentesis because of advanced maternal age. Paternal age was 40. The pregnancy was uncomplicated, and ultrasound examination at 17 weeks of gestation demonstrated a fetus of normal size with no apparent anatomic abnormalities.

Cytogenetic evaluation of GTG-banded preparation from fetal cells obtained from amniotic fluid demonstrated a female karyotype with an unbalanced aberration that was diagnosed as a tandem inverted duplication of the short arm of a chromosome 10 homologue

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(chromosome and fluorescence in situ hybridization (FISH) studies described below). Parental peripheral blood karyotypes are normal.

Termination of pregnancy was performed at 20 weeks gestation. At the request of the parents, an autopsy was limited to the chest and abdomen. The female fetus weighed 276 g and had crown-rump, head circumference, and heel-toe lengths of 17.8 cm, 15.6 cm, and 3.2 cm respectively. All of these measurements and the weights of fetal organs are within two standard deviations of respective means for a gestational age of 20 weeks and body weight [18, 41]. The fetus had an abnormal face with apparently low set, posteriorly angulated ears, cleft soft palate, ocular hypertelorism, and a small upturned nose. The other external findings were normal except for unusual flexion of both thumbs at the interphalangeal joint. Agenesis of the gall bladder and bilobation of the right lung were the only internal anomalies. Radiographic studies demonstrated sacral hemivertebrae. The placenta, membranes, and cord were grossly normal. Histologic studies of the viscera and placenta demonstrated no pathology.

METHODS

All preparations from the amniotic fluid specimens and tissues obtained at autopsy were GTG-banded according to the method of Seabright [39]. Amniotic fluid chromosome preparations were also C-banded by the method of Salamanca and Armendares [36]. The probes used in the FISH analyses were purchased from ONCOR (Gaithersburg, MD). All studies using the FISH probes were carried out according to the manufacturer's protocols.

RESULTS

Cytogenetics and FISH Analysis

All metaphase cells analyzed in a GTG-banded preparation showed extra material in the long arm of one chromosome 10 homologue that displayed a banding pattern consistent with the presence of an inverted tandem duplication of a large segment of the short arm with the centromere situated between the duplicated segments (Fig. 1). The results observed in QFQ and C-banded preparations are consistent with this interpretation. Only one region of staining between the two inverted segments was observed in the C-banded preparations. The abnormality was reported as: 46,XX,inv(10)(pter→cen::cen→p15::q11-qter).

FISH studies were carried out for further confirmation of our interpretation of the banded preparations. A whole chromosome 10 paint (ONCOR, catalogue # p5212) hybridized along the entire abnormal homo-

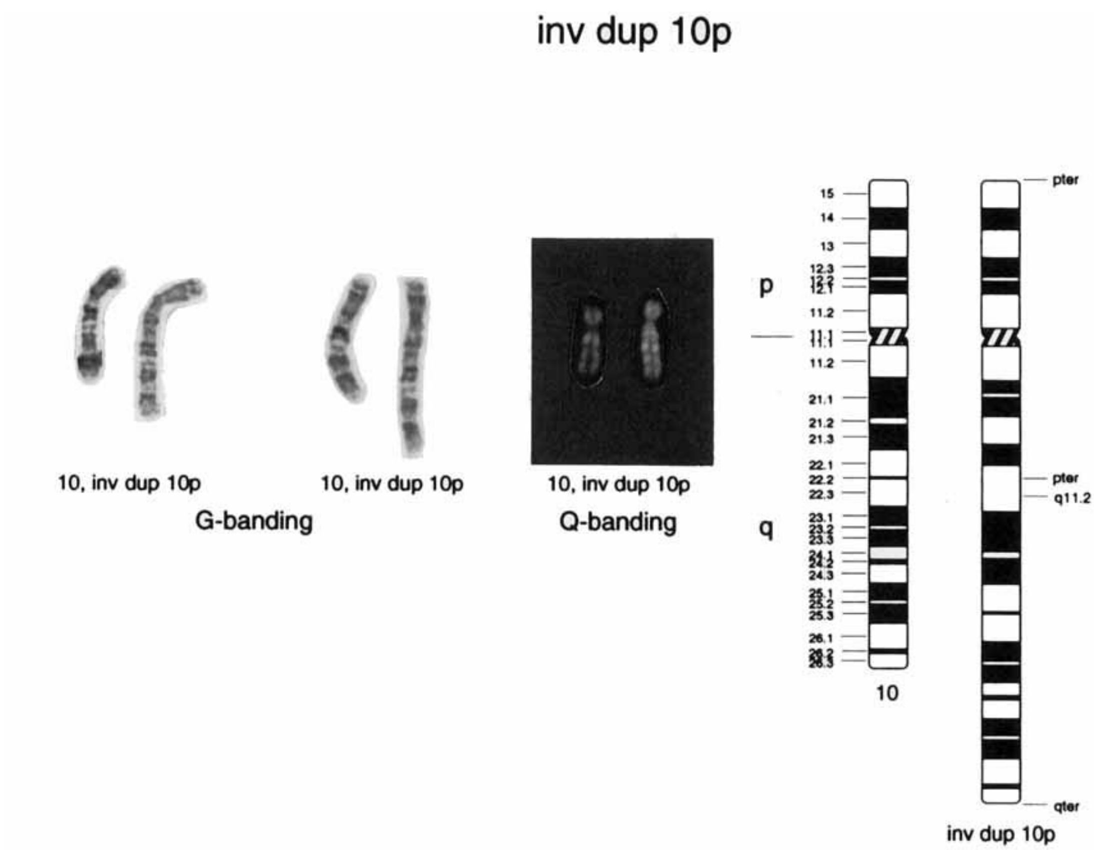

Fig. 1. G- and Q-banded partial karyotype of chromosome 10 from the patient. The banding pattern with both stains is consistent with a tandem inverted duplication of most or all of the short arm of chromosome 10. An ideogram depicting the aberration (assuming involvement of the entire arm) is shown at right.

logue (Fig. 2A). Hybridization with an all telomere probe (ONCOR, catalogue # p5097) showed three sets of signals in the abnormal chromosome in all 20 cells examined (Fig. 2B), two at the distal tips of the long and short arms and one set at the junction between the inverted short arm and the long arm. Hybridization with a chromosome 10-specific centromere probe showed two sites of hybridization along the abnormal chromosome; a prominent signal was observed at the junction between the inverted short arm segments and a weaker signal at the junction between the inverted short arm and the long arm could be seen in ~ 30% of the cells screened (Fig. 2C).

Literature Review and Karyotype-Phenotype Correlation

We have identified 60 cases of nonmosaic trisomy 10p with sufficient information to be included in this analysis. The chromosomal aberrations leading to causing 10p trisomy are shown in Table I. The translocation-derived trisomies have in turn been divided into two groups: (1) reciprocal translocations in which the 10p segment is translocated to the short arm of an acrocentric chromosome, and (2) reciprocal translocations in which the 10p segment is translocated to a chromosome region other than the short arm of an acrocentric chromosome.

The survey demonstrated a very strong bias toward the reporting of inherited cases of unbalanced translocations or recombinant inversions; only 2 of 55 cases (42 families) included in this study were reported as de novo. A maternal origin was documented in 28 of the 42 families with inherited aberrations identified in this survey. Deviation from a random distribution of parental origin is most marked in the group of translocations involving the acrocentric chromosomes where a maternal origin was reported in 7 of 8 families in which an inherited aberration was documented.

The frequency of 20 clinical manifestations described in cases of trisomy 10p are shown in Table II. Five of these—hypotonia, high-arched/cleft palate, frontal bossing, clubfoot, and nasal abnormalities—are described in 50% or more of the cases reviewed in this study. These abnormalities have been reported to be characteristic of patients with trisomy 10p [7]. However, other anomalies purported to be characteristic of the syndrome, such as dolichocephaly, mouth abnormalities, and delayed closure of sutures and fontanelles, were reported in < 50% of the cases included in this survey. Cardiac malformation and cystic dysplasia of the kidneys, the two most consistently reported malformations, were documented in 28% and 18%, respectively, of the cases included in this study (Table II).

Dividing the populations into the various subgroups shown in Tables I and II permitted us to compare the frequencies of a selected group of traits in patients with pure trisomy 10p and patients with an associated deficiency. Pure trisomy can arise as a result of tandem duplication or by other unusual rearrangements (columns 1–5, Table II), or more commonly by the unbalanced segregation of a translocation to the short arm of an acrocentric chromosome (column 6, Table II), in which case there is no deficiency of euchromatic material. A comparison of the frequencies of the defects in the subgroup with a pure trisomy and those with an associated deficiency showed few significant differences. A statistical analysis of the differing frequencies of high-arched/cleft palate and clubfoot, aberrations that exhibited the greatest differences in frequency between the populations with and without an associated

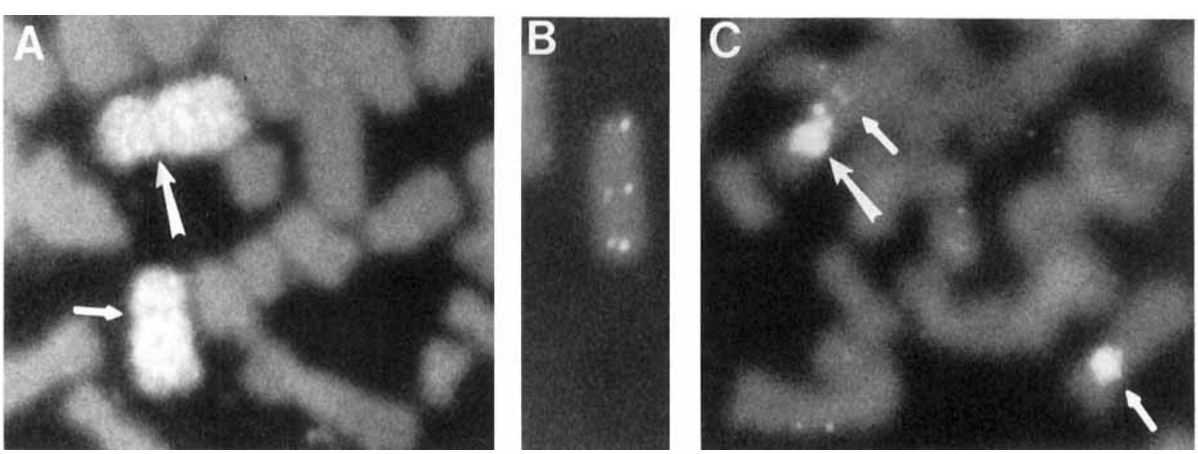

Fig. 2. Photomicrographs of FISH studies with a whole chromosome 10 paint (**A**); all telomere probe (**B**); and chromosome 10 specific centromere probe (**C**). The photomicrographs show hybridization signals in preparations counterstained with propidium iodide. Chromosomes were identified by actinomycin D and Hoechst staining, resulting in a Q-banded pattern (results not shown). In A, the arrows indicate the abnormal (larger arrow) and normal 10. Hybridization of all the telomere probe at the junction of the inverted short arm and the proximal long arm is evident in B. In C, signals produced by the chromosome 10-specific centromere probe between the inverted short arm segments are identified by the large arrow, and the fainter signal at the junction between the inverted segment of the short arm and the proximal end of the long arm by an adjacent small arrow. The other small arrow indicates the centromere of the normal 10.

TABLE I. Frequency of Various Types of Aberrations Causing Partial or Complete Trisomy 10p

Mechanism of trisomy	No. cases	No. families	Paternal/maternal inheritance ratio	References
Reciprocal translocation	32	25	9/15	2, 4, 7–9, 12–14, 16, 17, 22–25, 28, 31, 34, 35, 37, 40, 42, 44–46, 49
Translocation to the short arm of an acrocentric chromosome	12	9[a]	1/7	1, 3, 5, 6, 11, 15, 26, 30, 50, 52
Recombinant pericentric inversion	11	8	2/6	19–21, 27, 29, 33, 51
Tandem duplication	3	5	1ND 2 de novo	10, 38, present case
Miscellaneous:		2		
supernumerary 10p	1		de novo	32, 43
i(10p);t(6;10)	1		de novo	

[a] One case de novo.
ND = not determined.

deficiency (Table II), revealed marginally significant, higher frequencies in the populations with pure trisomy (Table III). In contrast, the frequency of cardiac defects, the most common visceral anomaly, was determined not to be significantly different in the two populations (Table III).

In the cases of pure trisomy, the proximal boundary (breakpoint) of the trisomic region was observed to be most commonly adjacent to the centromere in band p11. We therefore elected to analyze the frequency of these three clinical traits as a function of size as determined by breakpoint location, independent of the nature of the mechanism leading to the trisomic state (Table III). We observed no significant differences in the frequency of cardiac anomalies, a difference of borderline significance in the case of clubfoot as a function of the location of the breakpoint. However, frequency of high-arched/cleft palate was observed to be significantly higher in the subset with the largest trisomic segment (10p11→pter).

DISCUSSION

In this report, we have described an 17-week fetus with trisomy 10p resulting from the presence of a tandem inverted duplication of the entire short arm of chromosome 10. The presence of a hybridization signal at the junction between the telomeric end of the duplicated short arm and the long army in studies with both an all telomere probe and a chromosome 10-specific centromeric probe is consistent with a duplication of the entire short arm with no loss of material from the long arm of the abnormal chromosome. The presence of a relatively weak signal in the case of the centromeric probe is attributed to a reduced number of centromeric repeat sequences relative to the active centromere between the duplicated short arms. This interpretation could also explain the absence of visible staining of this site in the C-banded preparation.

Tandem inverted duplications are comparatively rare, although there is some evidence for a positive association with advanced paternal age [47]. In the absence of any reported mosaic cases it is likely that most if not all are of prezygotic origin. Models to explain the origin of these aberrations have been proposed [e.g., ref. 48]. Based on the observation from our FISH studies, we are proposing a meiotic mechanism that is similar to that proposed by Van Dyke et al. [48] with modifications to accommodate the pericentromeric distribution of the duplicated segments (Fig. 3).

The most common type of aberration leading to pure trisomy is translocation to an acrocentric short arm. In 11 of the 12 cases reported here, the breakpoint is at, or near, the centromere of chromosome 10, possibly reflecting some degree of homology between the chromosome 10 centromere and the short arm of the acrocentrics, which, if true, would mean that many of these cases are trisomic for the entire chromosome 10 short arm.

The other two cases of pure trisomy 10p arose by unusual mechanisms. In the case reported by Snyder et al. [43], the trisomic segment was shown to be present as a supernumerary acrocentric chromosome. Rivera and Rivas [32] described a fetus with isochromosome 10p and a translocation of 10q to the p arm of a chromosome 6. The interpretation of this rearrangement is based entirely on analysis of banded preparations; therefore, subtle aberrations, such as a small partial deficiency of 6p in the latter case cannot be excluded.

A comparison of the clinical anomalies in patients with pure trisomy 10p with those with a reciprocal deficiency of euchromatic material did not demonstrate a clearly distinguishable phenotype. However, two clinical traits, high-arched/cleft palate and clubfoot, were found to be more frequent in the patients with pure trisomy 10p at a borderline level of significance (Table III). The mechanism(s) by which coexisting monosomic and trisomic regions modulate the clinical phenotype associated with one or the other is unclear. Almost certainly, the association of a given clinical anomaly with both regions involved in the duplication/deficiency would be expected to have an additive effect. In this regard, cleft palate was documented in two patients with an unbalanced 4;10 translocation resulting in trisomy 10p and monosomy 4p, both of which are associated with this aberration [40]. Our study suggests that the presence of a deficiency can influence the frequency of specific features of the 10p trisomic phenotype. This effect could be the result of altered gene dosage. For ex-

TABLE II. Frequency of Selected Manifestations in 60 Patients With Trisomy 10p Grouped According to Type of Chromosomal Aberration Leading to the Trisomic State

Column	1	2	3	4	5	6	7	8	9
Type of aberration leading to trisomy	46,XX,−6,−10,+t(6;10)(p25;q11),+i(10p) [32]	46,XY,inv dup (10)(qter→p15.3::p15.3→p11.1) [38]	47,XX,+10p (pter→cen) [43]	46,XX,dup(10p) (pter→p12::p12::p12→qter) [10]	46,XY,inv dup (10p) [present case]	Translocation involving short arm of acrocentric, N = 12 (%)	Reciprocal translocation, N = 32 (%)	Recombination pericentric inversion, N = 11 (%)	Total population N = 60 (%)
Finding[a]									
Hypotonia	+	+	+		NE	5 (45)	18 (56)	6 (55)	32 (53)
Arched/cleft palate	+		+		+	10 (91)	18 (56)	5 (45)	36 (60)
Microcephaly	+	+		+		4 (25)	15 (47)	4 (36)	25 (42)
Dolichocephaly			+			5 (42)	7 (22)	3 (27)	16 (27)
Bossing of forehead						8 (68)	15 (47)	8 (73)	31 (52)
Ear abnormalities[b]	+	+		+	+	9 (75)	21 (66)	9 (81)	42 (70)
Ocular abnormalities[c]						3 (25)	7 (22)	2 (18)	12 (20)
Palpebral fissure abnormalities[d]						5 (50)	11 (34)	4 (36)	20 (33)
Hypertelorism					+	6 (50)	8 (25)	3 (27)	18 (30)
Cardiac abnormalities	+	+	+			5 (42)	8 (25)	1 (9)	17 (28)
Renal abnormalities			+			3 (25)	7 (22)	0 (0)	11 (18)
Clubfoot	+		+			9 (75)	14 (44)	5 (45)	30 (50)
Flexion abnormalities (digits and/or limbs)		+	+		+	5 (42)	6 (19)	3 (27)	17 (28)
"Carp-shaped" mouth			+			5 (42)	10 (31)	5 (48)	22 (37)
Skeletal abnormalities					+	2 (17)	2 (6)	1 (9)	6 (10)
Genital abnormalities[e]		+				5 (42)	11 (34)	3 (27)	20 (33)
Cheek pouches						1 (8)	5 (16)	3 (27)	9 (15)
Nose abnormalities[f]			+			7 (33)	21 (66)	8 (73)	34 (57)
Micrognathia						5 (42)	14 (44)	3 (27)	22 (37)
Clinodactly		+				3 (25)	10 (31)	2 (18)	16 (27)
Wide suture/fontanelle						4 (33)	6 (19)	3 (27)	13 (22)

[a]Mental retardation and postnatal growth failure could not be assessed in fetuses and infants in the perinatal period and, therefore, were not included in this analysis. Moreover, mental retardation is invariably described in patients old enough to assess and is almost certainly a constant finding in this anomaly.
[b]Ear anomalies included abnormal position, size, and shape (preauricular tags were described in three cases).
[c]Ocular anomalies included colobomata and microphthalmia.
[d]Palpebral fissure abnormalities included antimongloid slant and presence of epicanthal fold.
[e]Most common genital abnormalities reported are hypoplasia of external genitalia and clitoral hypertrophy.
[f]*All of the nasal abnormalities consisted of a broad protruding nasal bridge with flared nares.*

TABLE III. Comparison of the Frequency of Three Clinical Traits in Trisomy 10p as a Function of the Presence or Absence of Associated Monosomy and Size (Breakpoint Location) of the Trisomic Segment†

	Total (subgroup)	Cardiac anomalies	Clubfoot	Palatal abnormalities
With monosomy	39	8	17	19
Without monosomy (pure trisomy)	20[a]	7	14	15
Total	59[b]	—	—	—
P value		0.23	0.054*	0.953*
Trisomy p11→pter	43	14	23	31
Trisomy ≥p12→pter	16	4	8	5
Total	59			
P value		0.61	0.054*	0.004**

†The Pearson Chi-square statistical analysis was used to evaluate the significance of the differences in the frequency of these abnormalities in the various subpopulations defined by the type of chromosome abnormality. Adjustments for multiple constructs was carried out.
[a]Two cases (twins) in which diagnosis is 46,XX,t(10;12)p11;q24.4) were included in the pure trisomy group because the breakpoint is considered to be at the telomere and consequently a minimal or absent monosomic region [9].
[b]One case was excluded because of presence of trisomy 18q in addition to trisomy 10p, a result of a 3:1 segregation of 10;18 translocation.
*Considered to be of marginal significance.
**Statistically significant after adjustment for 6 contrasts.

ample, the reduction to a hemizygous state of a transcriptional regulatory gene may result in a reduction of the activity of a critical gene(s) in the trisomic region (or vice versa).

The results of our examination of the clinical phenotype as a function of the size of the trisomic region suggest that critical loci for high-arched/cleft palate are present in band 10p11. Insufficient numbers of cases with partial or complete pure trisomy 10p have been reported to carry out a more refined analysis to determine if trisomy of this region alone is sufficient to produce this palatal anomaly. However, it should be noted that high-arched/cleft palate was not observed in two cases of pure trisomy 10p in which 10p11 is not included in the trisomic region, whereas this anomaly was described in 14 of 15 cases in which this region is trisomic.

The objective of this analysis was to define a clinical syndrome uniquely associated with trisomy 10p. A variety of clinical defects, including dolichocephaly, frontal bossing, delayed closure of sutures and fontanelles, broad nasal root, mental retardation, triangular mouth with everted upper lip (carp-shaped mouth), clubfoot, high-arched/cleft palate, cardiac defects, and cystic dysplasia of the kidneys have been suggested to be characteristic or evocative of a 10p syndrome [7, 19, 23]. We observed that only clubfoot, palatal abnormali-

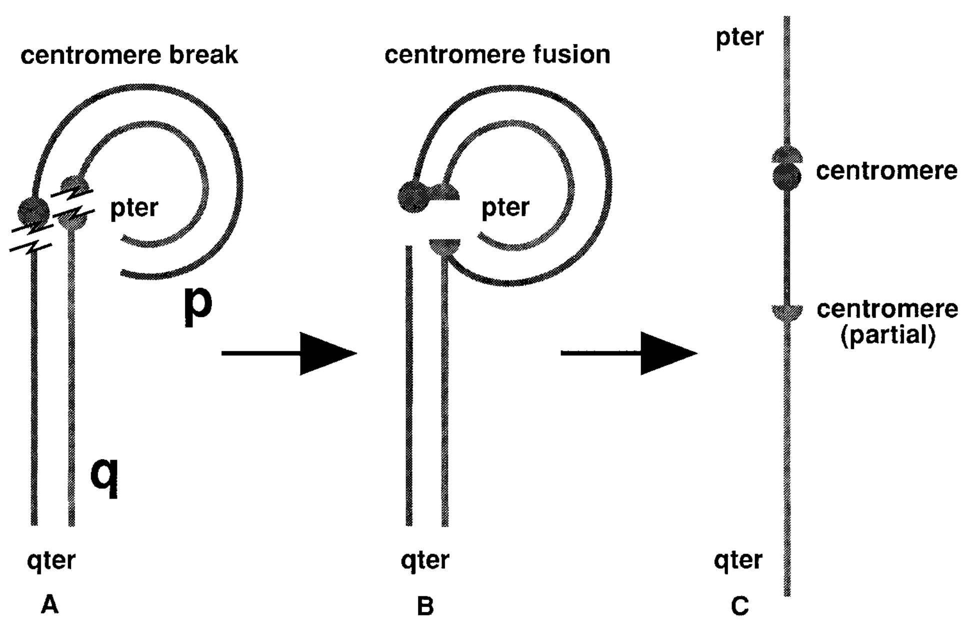

Fig. 3. Diagram depicting a possible mechanism for the formation of the tandem inverted duplication documented in this study. The process postulated here would have occurred in paired meiotic chromosomes. The initial events are breaks in the centromere of one homologue and at the junction between the long arm and centromere in the other homologue (**A**). The centromere on the two short arms fused and the telomere of the short arm of the chromosome with the break in the proximal long arm is ligated to the residual centromeric material on the long arm of the other homologue (**B**). This sequence of breakage and ligation would result in the pattern of hybridization observed in our studies (**C**).

ties, and frontal bossing were described in ≥50% of the patients with pure trisomy 10 that have been reported in the literature. We do not think that these results support the existence of a clearly defined syndrome associated with this aberration. More cases of pure partial and complete trisomy 10p must be identified and defined at the molecular level to determine if such a syndrome can be unambiguously identified.

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REFERENCES

1. Aller V, Abrisqueta JA, Pérez-Castillo A, del Mazo J, Martín-Lucas MA, de Torres ML (1979): Trisomy 10p due to a de novo t(10p;13p). Hum Genet 46:129–134.
2. Back E, Vogel W, Hertel C, Schuchmann L (1978): Trisomy 10p due to t(5;10)(p15;p11) segregating in a large sibship. Hum Genet 41:11–17.
3. Cantu J-M, Salamanca F, Buentello L, Carnevale A, Armendares S (1975): Trisomy 10p: A report of two cases due to familial translocation rcp (10;21)(p11;p11). Ann Génét 18:5–11.
4. Dallapiccola B, Chessa L, Vignetti P, Ferrante E, Gandini E (1979): Increased HK_1 activity levels in the red cells of a patient with a de novo trisomy 10p: t(Y;10)(p11;p12). Hum Genet 50: 45–49.
5. Dallapiccola B, Serena Lungarotti M, Magnani M, Dacha M (1981): Evidence of gene dosage effect for HK 1 in the red cells of a patient with trisomy 10pter→p13. Ann Génét 24:45–47.
6. de Chieri P, Spatuzza E, Bonich JM (1978): Brother and sister with trisomy 10p: 46,XY,(22p+)mat; 46,XX,(22p+)mat. Hum Genet 45:71–75.
7. Delaroche I, Bruni L, Giannotti A, Giampaolo R, Aebischer ML (1984): Trisomy for the short arm of chromosome 10: Report of a new case resulting from segregation of a maternal balanced translocation t(10qter→q11::14p11→qter). Helv Paediat Acta 39: 161–166.
8. Delicado A, Lopez Pajares I, Vicente P, Hawkins F (1979): Familial translocation t(10;21)(q22;q22). Hum Genet 50:253–258.
9. Farge P, Dallaire L, Potier M, Melançon SB (1985): Prenatal diagnosis of trisomy 10p in a twin pregnancy. Prenat Diagn 5:199–203.
10. Fryns JP, Deroover J, Haegeman J, Van den Berghe H (1979): Partial duplication of the short arm of chromosome 10: Karyotype: 46,XX,dup(10p)(pter→p12::p12::p12→qter). Hum Genet 47:217–220.
11. Gonzalez CH, Billerbeck AEC, Takayama LC, Wajntal A (1983): Duplication 10p in a girl due to a maternal translocation t(10;14) (p11:p12). Am J Med Genet 14:159–167.
12. Grosse K-P, Schwanitz G, Singer H, Wieczorek V (1975): Partial trisomy 10p. Humangenetik 29:141–144.
13. Herva R, Korhonen S, Haapala K, Timonen E (1983): Trisomy 10p produced by recombination involving complex paternal translocation between chromosomes 1 and 10. Clin Genet 24:50–53.
14. Hirschhorn K, Lucas M, Wallace I (1973): Precise identification of various chromosomal abnormalities. Ann Hum Genet (Lond) 36: 375–379.
15. Hustinx ThWJ, ter Haar BGA, Scheres JMJC, Rutten FJ (1974): Trisomy for the short arm of chromosome No. 10. Clin Genet 6: 408–415.
16. Insley J, Rushton DI, Everley Jones HW (1968): An intersexual infant with an extra chromosome. Ann Génét 11:88–94.
17. Johnson G. Bachman R, Roed T, Riddervold P (1977): Partial trisomy 10p and familial translocation t(7;10)(p22;p12). Hum Genet 35:353–356.
18. Kalousek DK, Baldwin VJ, Dimmick JE, Norman MG, Cimolai N, Andrews A, Paradice B (1992): Embryofetal-perinatal autopsy and placental examination. In Dimmick JE, Kalousek DK (eds): "Developmental Pathology of the Embryo and Fetus." Philadelphia: JB Lippincott Co, pp. 799–824.
19. Kozma C, Meck JM (1994): Familial 10p trisomy resulting from a maternal pericentric inversion. Am J Med Genet 49:281–287.
20. Kulharya AS, Schneider NR, Wilson GN (1993): Three cases of dup(10p)del(10q) syndrome resulting from maternal pericentric inversion. Am J Med Genet 47:817–819.
21. Lansky-Shafer SC, Daniel WL, Ruiz L (1981): Trisomy 10p produced by recombination involving maternal inversion inv(10) (p11q26). J Med Genet 18:59–61.
22. Lapière J-C, Verloes A, Herens C, Delfortrie J, van Maldergem L, Gillerot Y, Koulischer L (1992): Combined 10pter→p11 and 18pter→q11 trisomy in a 7-year-old child. Genet Couns 3:155–159.
23. Lurie IW, Lazjuk GI, Gurevich DB, Kravtzova GI, Nedzved MK, Shved IA (1978): Partial trisomy 10p in two generations. Hum Genet 41:235–241.
24. Magenis RE, Overton K, Wyandt H, Bergstrom T, Hecht F, Lovrien E (1975): Exclusion gene mapping utilizing patients with chromosome imbalance: The HL-A system as a prototype. Humangenetik 27:91–109.
25. Moric'-Petrovic' S, Lac'a Z', Krajgher A, Milos'evic J (1976): Deux cas de trisomie 10p partielle dus a une translocation paternelle t(10;18)(p13;q23). Ann Génét 19:195–197.
26. Nakagome Y, Kobayashi H (1975): Trisomy of the short arm of chromosome 10. J Med Genet 12:412–424.
27. Nomoto N, Nagauchi O (1979): A partial 10p trisomy. –46,XY, rec(10),dup p,inv(10)(p13q26)pat–. Jpn J Hum Genet 27:165A.
28. Obry E, Piussan Ch, Risbourg B, Dutrillaux B (1980): Trisomie partielle (10pter→10q21) et monosome partielle (21pter→21q21) dues a une translocation réciproque familiale équilibrée (10;21) (q21;q21). Ann Génét 23:216–220.
29. Ohba K, Ohdo S, Sonoda T (1990): Trisomy 10p syndrome owing to maternal pericentric inversion. J Med Genet 27:264–266.
30. Orye E, Van Haesebrouck P, Van Coster R, Van Mele B (1985): Trisomy 10p, due to an unusual translocation. J Genet Hum 33: 63–66.
31. Penchaszadeh VB, Coco R (1977): Trisomy for the short arm of chromosome No. 10. J Génét Hum 25:221–227.
32. Rivera H, Rivas F (1992): Isochromosome/duplication of 10p and translocation of 10q. Am J Med Genet 42:396–397.
33. Roberts P, Williams J, Sills MA (1989): A case of two inversion (10) recombinants in a family. J Med Genet 26:461–464.
34. Rochon M, Powell J, Blanchard R, Paré C, Lemieux B (1979): La trisomie 10p: étude clinique et biochimique. L'Union Méd Canada 108:1490–1493.
35. Rolland M, Bourrouillou G, Elana G, Colombies P, Regnier C (1977): Trisomie 10p partielle d'origine paternelle deux nouvelles observations dans deux familles différentes. Ann Génét 20: 209–213.
36. Salamanca F, Armendares S (1974): C bands in human metaphase chromosome treated with barium hydroxide. Ann Génét 17: 135–136.
37. Schleiermacher E, Schliebitz U, Steffens C, Rompe G, Schmidt U (1974): Brother and sister with trisomy 10p: A new syndrome. Humangenetik 23:163–172.
38. Schwartz S, Cohen MM, Panny SR, Beisel JH, Vora S (1984): Duplication of chromosome 10p: Confirmation of regional assignments of platelet-type phosphofructokinase. Am J Hum Genet 36: 750–759.
39. Seabright M (1971): A rapid banding technique for human chromosomes. Lancet 2:971–972.
40. Seiberth V, Kachel W, Knorz MC, Liesenhoff H (1994): Ophthalmic findings in partial monosomy 4p (Wolf syndrome) in combination with partial trisomy 10p. Am J Ophthalmol 117:411–413.
41. Shepard TH, Shi M, Fellingham GW, Fujinaga M, FitzSimmons JM, Fantel AG, Barr M (1988): Organ weight standards for human fetuses. Pediatr Pathol 8:513–524.
42. Slinde S, Hansteen IL (1982): Two chromosomal syndromes in the same family: Monosomy and trisomy for part of the short arm of chromosome 10. Eur J Pediatr 139:153–157.

43. Snyder FF, Lin CC, Rudd NL, Shearer JE, Heikkila EM, Hoo JJ (1984): A de novo case of trisomy 10p: Gene dosage studies of hexokinase, inorganic pyrophosphatase and adenosine kinase. Hum Genet 67:187–189.

44. Stengel-Rutkowski S, Murken JD, Frankenberger R, Riechert M, Spiess H, Rodewald A, Stene J (1977): New chromosomal dysmorphic syndromes. 2. Trisomy 10p. Eur J Pediatr 126:109–125.

45. Stoll C, Willard D (1980): La trisomie 10p. A propos d'une observation due a une translocation maternelle. Pediatrie 35:251–255.

46. Turleau C, Doussau de Bazignan M, Roubin M, de Grouchy J (1976): Trisomie 10p. Une observation ancienne précisée par marquage. Ann Génét 19:61–64.

47. Van Dyke, DL (1987): Inverted tandem duplications. In Daniel A (ed): "Cytogenetics of Mammalian Autosomal Rearrangements." New York: Alan R Liss, pp. 642–643.

48. Van Dyke DL, Miller MJ, Weiss L (1983): The origin of inverted tandem duplications, and phenotypic effects of tandem duplication of the X chromosome long arm. Am J Med Genet 15:441–450.

49. van Wouwe JP, Wijnands MC, Mourad-Baars PEC, Geraedts JPM, Beverstock GC, van de Kamp JJP. (1986): A patient with dup(10p)del(8q) and Pendred syndrome. Am J Med Genet 24: 211–217.

50. Yanagisawa S, Adachi K (1970): [A case of multiple congenital anomalies with familial C-G translocation.] [Jpn J Hum Genet] 14:309–315.

51. Yunis E, Torres de Caballero OT (1981): Duplication deficiency as the result of meiotic segregation of a maternal inv(10). Hum Genet 57:71–74.

52. Yunis E, Silva R, Giraldo A (1976): Trisomy 10p. Ann Génét 19: 57–60.